Inefficient Investment Waves

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Investment Waves

- supply of financing tend to be procyclical
- in booms: more projects are financed $\Rightarrow$ high investment, low returns
- in recessions: less projects are financed $\Rightarrow$ low investment, high returns
Aggregate Investment Waves: Corporate loans/bonds
Industry Investment Waves: Low Profitability after Booms

- Hoberg-Phillips (JF, 2010):
  \textit{In competitive industries, we find that high industry-level stock market valuation, investment, and financing are followed by sharply lower operating cash flows}

- suggesting the role of pecuniary externality
Inefficient Investment Waves

- do investment waves arise by simple financing frictions (without persistent shocks in technology)?
- are these investment waves (constrained) inefficient with pecuniary externalities?
- if yes, too much investment in booms, too little investment in recessions or both?
- should the government intervene in booms/recessions or both?
Main Results

- tractable dynamic model of trade and investment:
  - aggregate cash constraint $\Rightarrow$ (constrained) efficient investment waves
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  - aggregate cash constraint $\Rightarrow$ (constrained) efficient investment waves
  - unverifiable idiosyncratic investment-opportunities $\Rightarrow$ (often) two-sided inefficiency
    - in booms: too much investment, too little cash holding
    - in recessions: too little investment, too much liquidity hoarding

- applications: (1) housing cycle, (2) industry cycles, (3) financial development and growth
Main Results

• tractable dynamic model of trade and investment:
  • aggregate cash constraint $\Rightarrow$ (constrained) efficient investment waves
  • unverifiable idiosyncratic investment-opportunities $\Rightarrow$ (often) two-sided inefficiency
    • in booms: too much investment, too little cash holding
    • in recessions: too little investment, too much liquidity hoarding
• were government intervene only in the recession
  • makes over investment in booms worse
  • even if effective, might make everyone worse off
• applications: (1) housing cycle, (2) industry cycles, (3) financial development and growth
A Simplified 2-Period Example: Setting

- ex ante identical agents with 1 **capital** \((K)\), c **cash** \((C)\)
  - in this example ”capital” and ”cash” are symmetric
- period 0, **investment**: either convert 2 units of cash to a unit of capital, or 2 units of capital to a unit of cash
- period 1: **skill shocks** and **trade**
  - half agents can obtain 3 units of consumption from each unit of capital in period 2
  - other half can obtain 3 units of consumption from each unit of cash (via new investment opportunity) in period 2
  - before final production but after idiosyncratic skill shocks, agents can **trade** capital among each other at price \(p\)
- period 2: **produce** and **consume**
• individual’s problem at period 0

$$\max_{K^i, C^i} \frac{1}{2} \left( K^i + \frac{C^i}{p} \right) 3 + \frac{1}{2} \left( K^i p + C^i \right) 3$$

subject to the investment technology $F(K^i, C^i) = 0$

• period 1 market clearing price

$$p = \frac{0.5C}{0.5K} = \frac{C}{K}$$

ex post efficient allocation
A Simplified 2-Period Example: Technology

\[ C', C \]

\[ |\text{slope}| = 1/2 \]

\[ 1 \]

\[ |\text{slope}| = 2 \]
A Simplified 2-Period Example: Social Optimum

\[
\max_{K,C} \frac{3}{2} \left( K + \frac{C}{C/K} \right) + \frac{3}{2} \left( C + \frac{K}{C} \right) = 3(K + C)
\]
A Simplified 2-Period Example: Market Solution I.

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\[ \max_{K,C} \frac{3}{2} \left( K + \frac{C}{C/K} \right) + \frac{3}{2} \left( C + \frac{K}{K} \right) = 3(K + C) \]

\[ \max_{K^i,C^i} \frac{3}{2} \left( K^i + \frac{C^i}{p} \right) + \frac{3}{2} \left( C^i + K^i p \right) \]

\[ MRS^i = \frac{(1/2)(3+p^3)}{(1/2)((1/p)^3+3)} = p \]

\[ |\text{slope}| = 2 \]

\[ MRS^i = p = C/K = c > 2 \]
A Simplified 2-Period Example: Market Solution II.

Market solution:
Overinvestment in $K$

$|\text{slope}| = 2$

$\text{MRS}_i = p = C/K = 2$
A Simplified 2-Period Example: Market Solution III.

\[ \text{MRS}_i = p = \frac{C}{K} = c < \frac{1}{2} \]

\[ |\text{slope}| = \frac{1}{2} \]
A Simplified 2-Period Example: Market Solution III.

Market solution: Overinvestment in $C$.

|slope| = 1/2
How Does Price Affect Rent Distribution?

- form social perspective: each unit of $C$ or $K$ produces 3 units of utils, independent of idiosyncratic skills
- individual agent in addition cares about **rent distribution** due to trade after realization of idiosyncratic skills
  - each unit of capital will deliver either 3 (if $K$ type, no trading), or $3p$ (if $C$ type, selling capital, taking new opportunities)
  - if $p > 1$, how does capital generate $3(p - 1)$ more than its social value when selling?
  - because the trading partner suffers relative to the social value
  - the capital buyer spends $p$ amount of cash to get 3 utils, thus a return of $3/p$. So he loses $3 - 3/p$ of rent
Market Frictions in Background

• in general, the economy suffers from missing market problem

1. the final period 2 output not fully pledgeable (e.g. stealing)
   • otherwise $C$-person could hire $K$-person to operate capital

2. no contract allowed on period 1 individual skill shocks (e.g. misreporting)
   • otherwise Arrow-Debreu securities will help (though, there is no aggregate uncertainty)
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3. investing before knowing the shocks
   - ex post heterogeneity (idiosyncratic skill shocks) is important for rent distribution. otherwise, constrained efficient
from Static Insight to Dynamic Model

- ex post trading and price ensures efficient allocation, but distorts ex ante investment incentives
  - higher (lower) price, more rent goes to capital (cash)
  - a form of **pecuniary externality**
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  - relative scarcity may fluctuate with business cycle
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- the formal dynamic model: capital produces cash stochastically, solve for interim prices and investment, generalize the two-sided inefficiencies
  - ”boom”: past good cashflow shocks drive up current cash-to-capital ratio, leading to investment in capital
Model I

- consumption good and capital good: cash $C_t$, capital $K_t$
- final date $\tau$, with intensity $\xi$: capital produces $R$
- before it arrives, generate positive or negative cash (AK technology, non-persistent cashflow shocks) $dC_t = K_t \sigma dZ_t$
  - if negative, capital needs maintenance
  - cash-to-capital ratio $c_t \equiv \frac{C_t}{K_t}$, so that $dc_t = \sigma dZ_t$
- market populated by long-lived risk neutral firms who can:
  - invest: build new capital for $h$
  - disinvest: dismantle capital for $l (< h)$
  - trade capital for market price (in terms of cash) $p_t$
- zero discount rate, storage technology available
Model II

- no outside cash
- unverifiable idiosyncratic shock: in final date firms learn that they differ in their skills
  - half "hit by skill-shock" : can invest in new technologies \( u > 1 \), but cannot use capital (produce 0)
  - half "are not hit": cannot invest in new technologies, but experience productivity hike on capital (produce \( R \) per unit)
- a last round of trade at \( \tilde{p}_\tau = c_\tau \) before production or investing into new technologies
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- cash vs capital: cash is safe asset, ready to consume, and fungible to be used in any alternative new technologies
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Timeline

Ex ante

Skill shocks realized

Ex post

Firms trade capital for \( \hat{p}_\tau = c_\tau \)

Firms produce \((R)\), invest in new opportunity \((u)\) and consume proceeds

Every instant: firms build, liquidate and trade capital, choose \( d\alpha^i_t, dK^i_t, K^i_t, C^i_t \), interim shock \( dC_t \) is realized, price \( p_t \) is set

\[
\max \left\{ d\alpha^i \geq 0, K^i \geq 0, C^i \geq 0, dK^i \right\}
\]

\[
\mathbb{E} \left\{ \int_0^{\infty} \xi e^{-\xi \tau} \left( \int_0^\tau d\alpha^i_t + \left[ \frac{1}{2} \left( K^i_t + \frac{C^i_t}{\hat{p}_\tau} \right) R + \frac{1}{2} \left( K^i_t \hat{p}_\tau + C^i_t \right) u \right] \right) d\tau \right\}
\]

s.t. \( w^i_t \equiv p_t K^i_t + C^i_t \geq 0 \), \( dw^i_t = -d\alpha^i_t - (1_{dK^i_t > 0} h + 1_{dK^i_t < 0} l) dK^i_t + K^i_t (dp_t + \sigma dZ_t) \)
Solving for the Equilibrium

- looking for standard symmetric Walrasian equilibrium
- scale invariant, uni-dimensional state variable cash-to-capital ratio: \( c_t \equiv \frac{C_t}{K_t} \)
- value function is separable in capital \( K^i_t \) and cash \( C^i_t \)

\[
J \left( C, K, K^i_t, C^i_t \right) = K^i_t v(c) + C^i_t q(c).
\]

- value of cash \( q \) always greater than 1, never consume ex ante
- closed form general solutions for \( v(c) \) and \( q(c) \)
• pricing by indifference:

\[ p(c) = \frac{v(c)}{q(c)} \]

• linear technology, each firm builds capital when \( p = h \) (\( c_t \) hits investment threshold \( c_h^* \)), and liquidate capital when \( p = l \) (\( c_t \) hits disinvestment threshold \( c_l^* \))

• aggregate liquidity \( c_t \) fluctuates between reflective barriers \( c_h^*, c_l^* \) so that

\[ p(c_h^*) = h, p(c_l^*) = l \]
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**Price of capital**

aggregate cash-to-capital ratio, $c = \frac{C}{K}$

**Value of cash**

aggregate cash-to-capital ratio, $c = \frac{C}{K}$

**Value of capital**

aggregate cash-to-capital ratio, $c = \frac{C}{K}$
Constrained Efficient Benchmarks

- **constrained efficient benchmark**: social planner regulates investment/disinvestment policies \( c_l^P, c_h^P \)
  - not affect ex-post allocation which needs private information
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- **constrained efficient benchmark**: social planner regulates investment/disinvestment policies $c_l^P, c_h^P$
  - not affect ex-post allocation which needs private information
- recall: market solution has efficient ex post allocation, but inefficient ex ante investment
- consider the **complete market benchmark**: either idiosyncratic shocks are verifiable or $R, u$ are pledgeable
- both benchmarks lead to same ex-ante value and same thresholds: $c_l^P, c_h^P$, in general different from market policies $c_l^*, c_h^*$
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**Price of capital**

\[
p(c), \ p_{cm}(c)
\]

**Value of cash**

\[
q(c), \ q_{cm}(c)
\]

**Value of capital**

\[
v(c), \ v_{cm}(c)
\]
Externalities and Business Cycle

- missing market to trade the state of skill-shock ⇒ distorted ex-post price ⇒ distorted relative liquidity change incentives to store wealth in cash/capital ⇒ distorted ex-ante price ⇒ distorted investment thresholds

- contribution: price distortion changes sign with business cycle!
Application I: One-sided interventions

- suppose government realizes only the inefficiency in recessions
- when $p$ gets close to $l$ intervene:
  - one-sided intervention: tax cash / subsidize capital, keep a balanced budget, stop whenever price is high enough
- if two-sided inefficiency: one-sided intervention makes over investment in booms worse
- adverse effect in booms can be so bad that ex-ante welfare goes down everywhere, even in recession
Application II: Industry Booms and Busts

- Hoberg-Phillips (JF, 2010)
- only in **competitive** industries: high valuation, investment, financing predicts low profitability
- their story: signal extraction problem from return shocks
- our story: no contracts on future investment opportunities
  \[\Rightarrow\] pecuniary externality
  - would not occur in a non-competitive setting where agents take into account their price effect
  - (we show this formally for the two-period version)
Application III: Inefficient Construction Waves

• consider a real-estate developer who faces different investment opportunities each time (i.e., Donald Trump)
• has to decide how to store his capital for future opportunities
• our model: relative liquidity of capital and consumption good varies over the cycle
  • bad times: real estate can be sold only with a deep discount, prefers to hoard cash, push price even further, disinvestment
  • good times: real estate can be sold for high price, liquid store of value, push price higher, developer builds more
• "Reverse fire-sale" pattern in Japan:

*It took most Japanese banks years to whittle down the tens of billions of dollars in unrecoverable loans left on their books after the collapse of a real estate bubble* [...] *But analysts criticize most banks for failing to find new, more profitable – and less risky – ways of doing business. Instead, analysts say many have gone back to lending heavily to real estate development companies and investment funds, as the rebounding economy has touched off a construction boom in Tokyo. "If the economy stalled, Japanese banks would have a bad loan problem all over again,” said Naoko Nemoto, an analyst for Standard & Poor’s in Tokyo. (The New York Times, January 17, 2006)
Application IV: Financial Development and Growth

- Aghion et al. (2010): less financially developed countries → more volatile, more procyclical investment in riskier/more productive projects
  - market incompleteness: less financial development
  - investment in capital $dK_t$: investment in riskier/more productive projects
Alternative Specification

- coincident timing of $u$ shock and $R$ shock is not important
- more natural but less tractable. In each instant:
  - with intensity $\phi$ capital matures as in the main model
  - during $[t, t + dt]$, $\xi dt$ fraction of agents are hit by new opportunities, sell capital and invest outside for $u$
- instead of ex-ante price and ex-post price, just price to serve both (conflicting) roles
  - determines terms of transfer for exit (thus the flow to new investment opportunities)
  - drives investment decisions of capital
- the first role regarding rent distribution fluctuates with cycles, distorts the second role (and investment)
Literature

  - Investment with inaction region: Abel and Eberly (1994)
Conclusion

- constraint on aggregate capital: investment waves, can be constrained efficient
- unverifiable idiosyncratic shock for relative value of productive assets and cash: inefficiency
  - ex post cash-in-the-market price ensures efficient allocation, but distorts ex ante incentives
  - a form of pecuniary externality
  - the sign of distortion depends on relative supply
- dynamic model:
  - relative supply is given by the state of the cycle
  - policy experiments with agents appreciating the eternal fluctuation
- cool framework: fully dynamic model with analytical tractability, useful for other questions